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A TREATISE OF THE REASON OF Muſcular Motion:

Or the Efficient Cauſes of the *Contraction of a Muſcle.*

WHEREIN

Moſt of the *Phænomena* about *Muſcular Motion* are explained.

By *RICHARD BOULTON*, of the City of *Cheſter*, *Medicin. Proficiens.*

Τὰ ἅπαντα συμπνοῦν καὶ συῤῥοῦν.

LONDON,
Printed by *A.* and *J. Churchill*, at the *Black Swan* in *Pater-Noſter-Row*, 1697.

TRactatum hunc cui Titulus (*A Treatiſe of the Reaſon of Muſcular Motion*, &c.) dignum Cenſemus, quî Imprimatur.

Samuel Collins, Præſes.

Thomas Burwell, Sen.
Richard Torleſs,
William Dawes,
Thomas Gill,
} Cenſor.

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TO THE

MOST LEARNED

AND

EVER HONOURED

Dr. *Collins*, Preſident:

Dr. *Thomas Burwell*,
Dr. *Richard Torleſſe*,
Dr. *William Dawes*,
Dr. *Thomas Gill*.

CENSORS

OF THE

Colledge of Phyſicians;

This Treatiſe is Humbly Dedicated

By Your Moſt Faithful

And Obedient Servant

R. BOULTON.

TO THE READER.

I Have examined this Treatise with the strictest Reason that I am Master of; and it appears to me Reasonable, in every Particular.

But I am altogether desirous of Truth, and would not out of any fond Opinion of my own Hypothesis, receive it sooner than another Man's. I am most inclined to suspect whatever is a Fætus of my own Brain.

If it may be any ways servicable to others, I have my Desire.

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OF

OF THE

REASON

OF

Muſcular Motion:

OR,

The Efficient Cauſes of the Contraction of a Muſcle, &c.

IF we conſider the Uſefulneſs of Muſcular Motion, with reſpect to an Individual; and that, either as it tendeth

The Uſefulneſs of Muſcular Motion, as it tends to the maintenance of life.

to the maintenance of Life, or the perfection of Man, that is, with reſpect to the Soul, and the Animal Functions; it is the very ſpring upon which all our Actions, both Natural, Vital and Animal wholly depend. By the Aſſiſtance of Muſcular Motion, all the parts of our Body perform their particular Offices: Our Food is prepared by Maſtication, and conveyed to the Stomach; the concocted *Chymus* is thence expelled into the *Inteſtines*, where the pureſt *Chyle* is ſeparated from the impurer *Fæces*; every peculiar Liquor circulates through its diſtinct and proper Veſſels The *Chyle* through its *Lacteals* and the *Lympha* through its Ducts; and the Maſs of Blood

is distributed through the Arteries, that all the Parts of the Body, both Principal and Subsubservient, Noble and Ignoble, may receive their proper Liquors: In a word, it is by this very Action of Muscular Motion, that τὰ δ' πάντα συμπνεῖν καὶ συζῆν.

With respect to the Soul and its Functions.

If we respect the Animal Functions, they so much depend upon Muscular Motion, that when the Heart ceaseth to move, all the Faculties of the Soul are presently extinguish'd. The Faculties of the Soul are not only dependent on Involuntary, but also Voluntary Motion; without which, both our Eyes and Ears would be unfit to receive ex-

ternal Objects; and Man would be endowed with a Senſitive and Rational Soul to no purpoſe. Our outward Senſes would in vain receive external Objects, unleſs we had an Intelligent Faculty; in vain ſhould we Underſtand, unleſs we had Reaſon to diſtinguiſh good from evil, that we might deſire the one, and contemn the other: In vain alſo would be the Dictates of our Reaſon, if we had not a *Loco-Motive* Faculty, to purſue thoſe things we deſire, and to flee from thoſe things which we are willing to avoid. But by Muſcular Motion, the Dictates of our Reaſon, accordingly as they are byaſſed by our Appetites, are put into Action, and the intimate reſults

of

of all our Faculties are brought to light. Muſcular Motion is the very *Index Animi*, by which the Temper and Diſpoſition of the Animal Faculties are made evident; it's the Ultimate Reſult of our moſt ſecret Thoughts and of our Will; ſo that if we weigh but the mutual dependance of all the Parts of a Man's Body, there is no Reaſon, that a Muſcle ſhould be termed an Ignoble part; ſince by the loſs of a ſingle one, either the Natural, Vital, or Animal Faculties are in ſome meaſure vitiated.

A Muſcle is a Noble part.

The Stomach, the Liver, the Spleen, the Lungs, *&c.* are all ſubordinate and ſubſervient to the Principle Faculties of the

Soul; in as much as they by their mutual *Symbolums*, prepare the *Pabulum* of the Animal Spirits. But the Muſcles deſigned for Motion, eſpecially Voluntary (in as much as the moſt perfect and refined Actions of the Soul, are performed and expreſſed by Muſcular Motion,) are of a more noble uſe, the perfection of Man conſiſting more immediately on the energy and execution of the Principal Faculties of the Soul, than in the ſubordinate and ſubſervient Faculties, both Natural and Vital.

For as much as the Life and Perfection of Man, ſo much depend on Muſcular Motion, I ſhall

ſhall enquire into the Efficient Cauſes of it: But before I propoſe my own Hypotheſis, it is neceſſary that I firſt confute what has hitherto been ſaid on this ſubject; nevertheleſs, becauſe it would be too tedious to examine the Opinions of ſo many Authors, I will only ſhew the Errors of Two or Three of the lateſt and moſt conſiderable.

Dr. Willis's Opinion examin'd.

The moſt Learned and Famous Dr. *Willis* Conjectures, that the Spirits are conveyed to the Tendons of a Muſcle, and are there plentifully laid up as in a convenient Store-houſe; which Spirits be-

ing of an Agile and Elaſtick Nature, as far as they are able, and are permitted, always endeavour to expand themſelves; and that when an Inſtinct to perform Muſcular Motion, is carried from the Brain or *Cerebell*, to this common Storehouſe, they preſently leap out of the Tendinous, into the fleſhy Fibers, where they meet with active Principles of another Nature, ſupplied by the Maſs of Blood; which two ſtrongly & mutually fermenting, ſtuff up and tumifie the Fleſhy Fibers; whence proceeds the Contraction of a Muſcle. When the Contraction ceaſeth, he thinks that moſt of the pureſt Spirits that remain, return into the Tendons, the other more impure

impure Particles remaining amongſt the Fleſhy Fibers; he fancies, that the Fibers of the outward Membrane contracting, promote the Retroceſſion of the Spirits into the Tendons; and that for a continual ſupply of theſe Liquors, the one is always ſtored up in the Tendons, through the Nerves; and the other in the Carnous Fibers, from the Maſs of Blood.

No Elaſtick Spirits laid up in the Tendons.

This Conjecture as it ſeems ingenious, and at the firſt view very myſterious, yet upon a more ſtrict Examination, it appears altogether as improbable. For to ſuppoſe that theſe Elaſtick Spirits are laid up, and ſtored in the Tendi-

nous Fibers, is contradictory to Reaſon, as well as the Laws of Circulation; for ſince in every Syſtole of the Brain, a freſh ſupply of Animal Spirits is ſent into all the Branches of the Nerves, thoſe Animal Spirits in the Tendinous Fibers, muſt needs by a ſucceſſion of new matter, be preſſed forwards into the Fleſhy Fibres; and conſequently Accidental Contractions muſt follow: for as much as there are no Valves to hinder their immediate Paſſage. And that there are no Valves, nor any thing elſe to ſtop the continual Paſſage of theſe Spirits, may be argued hence; becauſe whatever would ſtop the protruſion of theſe Spirits, when preſſed by the Syſtole

ſtole of the Brain, would alſo hinder 'em from ruſhing out of their Store-houſe, though ſtirred up by an Inſtinct, and ſo the Muſcle would be deprived of Motion.

But ſuppoſing that it were poſſible for theſe Elaſtick Spirits, to be ſtored up in the Tendinous Fibers, and that neither their agility, and continual Endeavours to exploſion, nor the force of ſucceeding Spirits would drive 'em out; yet when a Muſcle ceaſeth from Motion, perhaps a Day or Two; the Tendon would be ſo filled and ſtuffed up, that being no longer capable of receiving more Spirits, either they muſt be forced forth into the Carnous Fibers, and cauſe violent and Involuntary

tary Contractions; or regurgitating and flowing back upon the Brain, would there cauſe a *Vertigo*, or ſome other more fatal Diſeaſe; and beſides the Spirits by ſtagnating ſo long, would be chilled and coagulated, and thereby render'd unapt for Motion.

Nor inſtinct ſent from the Brain, becauſe

It is not only abſurd to imagine, that the Tendons, are Storehouſes for Spirits; but alſo that they, the Inſtinct being given, ſhould ruſh out of the Carnous Fibers; one might as well think, that the Contents of the Stomach, the Gall in the *Veſica Bilaria*, or the Urine in the Bladder, might be excluded by inſtinct, meerly without the help

help of Muſcular Coats; or that the Circulation of the Blood might be carried on, without the Syſtole and Diaſtole of the Heart.

Moreover, to allow, that thoſe Elaſtick Spirits do after this manner ruſh into the Carnous Fibers, when the Inſtinct is given from the Brain, or to ſpeak more properly, *ad imperium animæ*, either implies, that thoſe Spirits, which Dr. *Willis* calls *Materiam ſubtilem*, are intelligent Matter; that they are able to underſtand the Dictates and Commands of the Soul; and to put them in Execution, *proprio motu*; or that ſome Spirits of

Either it implies, that the Spirits are Intelligent,

Or that Spirits of a Different Nature are ſent from it.

of a Different Nature, are at the command of the Soul, ſent from the Brain, which cauſe the Spirits in the Tendons to be uneaſie, and by exagitation to expand themſelves more powerfully, and conſequently to leap forth. But if neither the texture of thoſe Spirits, which as Dr. *Willis* ſays, give the Inſtinct, be changed, and different from thoſe in the Tendons, nor the Subtile Matter be Intelligent, there would be no Exploſion, or leaping forth of the Spirits out of the Tendons, either by inſtinct, or the acceſſion of new Matter from the Nerves; except, as I noted before, the Spirits which filled the Tendinous Fibers,

Fibers, were driven, and ſucceſſively forced out by a freſh ſupply of Spirits, ſent in by every Syſtole of the Brain; and ſo, Muſcular Motion would not be Voluntary, but Accidental.

That this Matter is not Intelligent, is proved ſufficiently; becauſe to allow that this acts as it receives Inſtinct from the Brain, is to allow a ſubordinate Soul which acts *propriâ facultate* in every Tendon; which is falſe; for an Intelligent Faculty in a Tendon, which muſt act according to the Dictates of the Principal Soul, cannot be ſuppoſed to be a Faculty of that Soul, no more than the Soul

The Matter is not Intelligent.

of

of a Diſciple, *Juratus in Verba Magiſtri*, and who exactly follows the Dictates of his Maſter, can be ſaid to be a part or faculty of his Maſter's Soul.

No Spirits of a different Nature are ſent from the Brain.

That no Spirits of a different Nature from thoſe he ſuppoſes to be in the Tendons, can be tranſmitted from the Brain, is evident. For ſince the ſame Spirits are diſtributed through all the Nervous Channels, from the ſame Fountains, the Brain, or the Spinal Marrow, whatever cauſes the Spirits to leap out of one Tendon, would cauſe the ſame Effects in all, and all the Muſcles muſt be contracted at the ſame Inſtinct.

Having

Having thus confuted the Grounds and Foundation of his Hypotheſis, it's not irrational to expect, that the whole Superſtructure ſhould fall: I ſhall only further take notice,

No active Principles heaped up in the Fleſhy Fibers.

Firſt, That if Active Principles of another Nature were heaped up in the Fleſhy Fibers, by degrees they would be ſo ſtuffed and ſwelled up, that there would be no room for the entrance of Elaſtick Spirits from the Tendons; but they themſelves would rather, by reaſon of their quantity, be forced into the Tendinous Fibers.

Secondly,

Nor retroceſſion of ſubtile Matter into the Tendons.

Secondly, That it would be abſurd to imagine, how theſe Two Spirits after ſo intimate a commixture, as would be produced by a ſtrong Fermentation, can be ſo eaſily ſeparated, that the one ſhould ſuddenly run back into the Tendons, leaving the other behind in the Fleſhy Fibers: For when Two Liquors of a different Nature, and whoſe Minute and Subtile Particles have a different Motion, are mixed together; by a mutual Fermentation is produced ſo intimate a mixture, that it is impoſſible to ſeparate the one from the other ſincere; becauſe by a mutual colliſion of different Particles, both muſt needs in ſome meaſure be

be altered, and degenerate from their Priſtine State, ſo that if the pureſt part of theſe Spirits remaining ſhould run back into the Tendons, they would be diſagreeable to, and different from thoſe purer Spirits ſent from the Brain; and would infect the Store-houſes with ſuch a fermentative taint, that as new ſupplys were laid down by the Nerves, freſh Exploſions and Contractions of the Muſcles muſt follow.

Thirdly, To help the Retroceſſion of theſe Spirits into the Tendinous Fibers; Dr. *Willis* would have the Fibers of the inveſting Membrance to contract: But I ſhould rather think, that they would contract at the ſame time with the Muſcle, if the Inſtinct

ſtinct were carried through the ſame Nervous Channels with the Spirits; becauſe, as he ſays, they are firſt laid down in the Membrane, and thence conveighed to the Tendon?

Mr. Cowper's opinion examined.

Mr. *Cowper*, in the Introduction to his *Myotomia Reformata*, ſuſpects; that the Blood is a Pondus, by which the action of a Muſcle is performed: The grounds of this ſuſpition are cheifly taken from two Experiments: The firſt is a Ligature on the deſcending ttunk of the Aorta, whereby all the inferior Parts, became deſtitute of Motion, which they recovered again when that Ligature was looſed: The ſecond, is

to

to be taken for a more ſurprizing Argument, becauſe after a ceſſation of Motion, the Muſcles of the Legs renued their Contractions, by an Injection of Water into the Crural Arterie.

But that there is no Reaſon to aſſert, that the Blood acts as a Pondus from theſe Experiments, will hereafter ſufficiently appear, by giving other Reaſons for theſe *Phenomena*.

In the mean time to evince, that the Blood as a Pondus does in no wiſe help the Contraction of a Muſcle, but does on the contrary, much interrupt and reſiſt the Intumeſcence of the Muſculous Fibers, by which the Contraction of a Muſcle is performed, let any one

The Blood does not act as a Pondus.

The Firſt Argument.

one hold his hands before a Fire, with his Arms perpendicular, continuing 'em in that poſture till he feels the Muſculous Parts well filled with Blood; then lifting up both his Hands, let him hold 'em up as high as he can, till the Pondus of the Blood be drained, and the Veins which before were full and tumid become flaccid and empty, and he'l move his Fingers much more eaſily and ſwifter, when the Muſcles are eaſed of the Pondus of Blood, than he did whilſt his Hands were dependent; yet certainly there was a greater Pondus of Blood upon the Muſcles in the former poſture, whilſt they were tumid, than in the latter when emptied of ſuperfluous blood.

Ano-

Another Argument to prove, That the Pondus of the Blood doth not at all promote the Contraction of a Muſcle ; may be taken from the Obſervation of Cacochymick Bodies, who are far more dull and unapt for Motion than healthful people, whoſe Veins and Arteries are moderately filled with Blood, which is not ſo thick and heavy ; for in Cacochymick Bodies, there is a greater Pondus of Blood, but becauſe it doth not yeild matter for to ſwell the Carnous Fibers, as plentifully as blood of a more healthful conſtitution, Motion is not ſo brisk and ſtrong ; whereas if the Pondus of the Blood did any ways contribute to the performance of Muſcular Motion,

A Second.

on, they would be far more ſtrong; for the thicker the Blood is, the greater is the Pondus.

A Third. In the Muſclesof the Legs and Thighs there is always, when the Body is erect, a greater weight of Blood, than on the Muſcles belonging to the Hands and Arms; and yet the latter, are far more agile and nimble in Motion.

Again, if we but make a Ligature two or three fingers breadth above the Cubit, ſo as to hinder the Reflux, but not the Influx of the Blood; when the Sanguiferous Veſſels are ſwelled, and the Muſcles well filled, they are rendered much more unapt for Motion: Which evidently ſhews that the more the Sanguiferous

ferous Veſſels are diſtended, the more the Motion of a Muſcle is hindered; becauſe when the Veſſels are dilated they reſiſt the Intumeſcence of the Carnous Fibers, and conſequently the Contraction of a Muſcle.

Furthermore, That the Contraction of a Muſcle is not perform'd by the Pondus of the Blood, is apparently evident in the following Experiment: *Viz.* Make a Ligature two or three fingers breadth above the Cubit, ſo ſtrong as to ſtop the Circulation of the Blood; then open the largeſt Vein with the common Inſtrument, and the Blood which more than uſually ſwelled up the Sanguiferous Veſſels will leap forth; but preſently for want of

A Fifth.

ſubſequent Matter, and due Circulation, the Vein falls and the Blood ceaſes to run; yet by a Contraction of the Muſcles to which that Vein leads, forthwith part of the Blood, which lay in the Muſcle, is forced out: which plainly ſhews there is leſs Blood in a contracted Muſcle, than before Contraction.

A Sixth.

The ſame appears alſo in Running, or any other violent Exerciſe, in which moſt of the Muſcles are Contracted; for preſently the Blood flows more than uſually upon the tender Lungs, and cauſes an Intollerable ſhortneſs of Breath: Becauſe by an Intumeſcence of the fleſhy Fibers, the Muſcles are not only made incapable of receiving ſo much Arterial

terial Blood as before Contraction; but alſo, becauſe the Blood which lay in the Veinous Ducts is driven out more forcibly upon the Heart, and the Heart being overwhelmed, drives it out upon the Lungs. Whence proceeds that Palpitation of the Heart upon violent Motion, not directly as Dr. *Croone* ſuppoſeth, becauſe an Inſtinct is ſent from the Brain to raiſe ſtronger Pulſations, that the Blood may forcibly be driven into the Muſcles, and thereby cauſe Contractions; for then why doth it not at the firſt Inſtinct thus oppreſs the Lungs with its quantaty? but this ſtrong Palpitation is Accidental; for when the Blood is more than uſually driven upon the Heart, and not ſo

plentifully received by the Muſcles; by degrees it oppreſſes the Heart with it's quantity, and the Animal powers being ſenſible of the oppreſſion, raiſe ſtronger Syſtoles to drive it out which preſently is received and heaped up in the Lungs as a Part leſs able to reſiſt its violent Incurſion. Nay many times, when the Veſſels are well filled with Blood, by violent and frequent Exagitations, betwixt the Contraction of the Heart and of the Muſcles, its texture is ſo looſened; that it ferments and boyles up ſo that the Lungs are not only ſwelled up and almoſt ſtifled, being rendered uncapable of receiving Air, but it is alſo more ſtrongly & forcibly driven into the Muſcles themſelves, and there

there diſtending the Sanguiferous Veſſels hinders the Intumeſcence of the Fibers, and thereby the Contractions of the Muſcles So that I have not once, trying this Experiment, found ſuch an Oppreſſion on my whole Thorax; and ſuch contrary and in ſome meaſure painful endeavours, betwixt the Sanguiferous Veſſels tumified and the Carnous Fibers ſtriving to ſwell; that I was forced to lay me down, to the end that the Carnous Fibers being flaccid might give way to the incourſe of the Blood; and by receiving it more plentifully might eaſe both my Thorax of its Oppreſſions; and that the Carnous Fibers yeilding to the Sanguiferous Veſſels might put an end

to that uneaſie contention. Thus much I think is ſufficient to prove, that the Blood as a Pondus hinders the Contraction of a Muſcle.

Dr. Ridley's Opinion examined.

Dr. *Ridley* ſuppoſes, That the Nervous and Carnous Fibers are only a Congeries of Fluids contained in certain Veſſels; and that by Reaſon of a Plenitude in the aforeſaid Veſſels, the whole Machine is in a conſtant *Æquilibrium*, ſo that it will follow, upon the common *Poſtulatum*, viz. That the Senſitive or Rational Soul can command the Animal Spirits into a *primus impetus*; and that part of that Liquor, whenever a Muſcle is Contracted, is tranſmitted

mitted through the Veſſels from the Brain to its Carnous Fibers, and cauſes the Intumeſcence of a Muſcle; the ſame Liquor at the ſame time being driven back with an equal ſpeed from the Antagoniſt Muſcle, into the room of the former, which was tranſmitted from the Brain to the Contracted Muſcle, to avoid a Vacuum.

That the Nervous Ducts as well as Carnous Fibers are always Watered with a Fluid; and that the Nervous Liquor equally flows into the Branches of all the Nerves, according to their Proportion, is beyond Contradiction; but if we allow the common *Poſtulatum*, we muſt alſo conclude,

The common Poſtulatum is not to be allowed.

That *the Animal Fluid* is Intelligent, and there will follow the ſame Difficulties as were before mentioned, about the leaping forth of Spirits out of Dr. *Willis* his *Tendinous Receptacles*; where I have given ſufficient Reaſons to reject this *Poſtulatum* as Impoſſible.

There is no Retroceſſion of a Fluid from the Antagoniſt.

Moreover if it were Poſſible, for ſo much of this *Animal Fluid* as is requiſite to diſtend the Carnous Fibers, to be conveiged in ſo ſhort a time as Muſcular Motion follows our Appetite through the ſmall Branches of the Nerves; yet it would be altogether unconceivable, how it ſhould flow back from the Antagoniſt, thus contrary to the

the Courſe of Circulation; but the Reaſon he gives is partly this, to avoid a Vacuum: This is a moſt Stupendious ſort of a Motion; at the ſame time that the Liquid is forced into the one Muſcle, it runs directly oppoſite from the Antagoniſt; which is very irregular and unlikely.

Nor is it forced out ſo as to cauſe a Vacuum.

Beſides, I cannot underſtand how it comes to paſs, that the Animal Fluid is ſo much forced out of the Branches of the Nerves leading to the Muſcles to be contracted as to leave a *Vacuum* for the Reception of Liquids from the Antagoniſt; but if an Emptineſs or Vacuum could be ſo made, the Fluids would as ſoon be drawn

back again, out of the Muſcles into which our Appetite directed them, to fill that empty Space, as out of the Antagoniſt.

To prevent an Objection againſt his Suppoſition, that the fluid runs back again from the Antagoniſt, he thinks he has anſwered it already, but very inſufficiently: He ſays, if it be ſaid, that the Reflux is oppoſed by the conſtant direct Motion, it's eaſie to reply, that it's ſlow direct Motion, is eaſily repelled, by the violent impulſe of the forcibly relaxed Muſcle. I muſt confeſs, it's no piece of difficulty to make ſuch an Anſwer; but the Reply ſeems not ſo eaſily to give ſatisfaction; I would fain know how

how the Antagoniſt comes to be ſo forcibly relaxed, as by a violent impulſe to overpower the direct Motion: For the direct Motion cannot be ſo weak, as to be eaſily overcome; and ſince the Animal Fluid, as he calls it, is continually driven by the Pulſation of the Heart, through the Brain or Spinal Marrow into the Nerves, whatever repells the direct Motion, muſt be of equal, if not greater, force than the Syſtole of the Heart.

He begs leave to ask, how when another bends his Arm againſt his Will, the Muſcles become tumid, as when voluntary contracted. This Queſtion doth not at all confirm his Hypotheſis, but on the contrary

pleads

pleads againſt it. It doth not confirm it, becauſe he doth not account for the *Phænomenon*, nor give a Reaſon agreeable to his Opinion, but leaves the thing barely without explanation; it pleads againſt him, becauſe according to his Opinion, the Muſcle inſtead of growing tumid, ought violently to relax, at leaſt to endeavour a relaxation, and not contrary to the Appetite, to run into a Muſcle againſt our Will: For he ſays at the ſame time, that the Muſcles to be contracted, grow tumid; the Antagoniſts by a violent relaxation, drive out the fluid contained in them: So that it will follow, that at the ſame time we endeavour to keep our Arm unbent, by ſtriving

ſtriving to keep the one Muſcle contracted, at the ſame time we ought to endeavour a relaxation of the Antagoniſt; and though that force which bends our Arm, doth reſiſt the Voluntary Contraction of the Muſcle, yet there would nothing hinder the voluntary Relaxation of that Muſcle, which is the Antagoniſt, but the ſlow direct Motion, as he calls it.

But here I humbly take leave to ask, whether there is not a great deal of difference, betwixt a Muſcle that is thus tumid, and one that is Contracted? For altho a Muſcle cannot but be tumid, when contracted, yet it may be tumid though not contracted: I mean, as it is in Muſcu-

Muſcular motion. I have indeed oft taken notice, that when my Arm has been bent againſt my Will, the Muſcles become tumid, but not as in Muſcular Motion; for when a Muſcle is Voluntarily contracted, it's hard and tumid; but when my Arm is bent againſt my Will, it's far more ſoft; and though tumid, yet very little contracted. Since the Reaſon why the Muſcles grow thus tumid, cannot be accounted for by this Hypotheſis, I ſhall explain it hereafter.

Having thus examined, and I hope confuted the aforementioned Opinions, I ſhall in the next place briefly conſider the Fabrick of a Muſcle, the immediate

mediate Inſtrument of Motion.

Anatomiſts, deſcribing the Fabrick of the Muſcles of the Body, divide 'em into Simple, Compound, and more Compound; as alſo every Muſcle into Three Parts, the Head, the Belly, and the Tail; they acquaint you how the Belly is compoſed of ſeveral *Faſciculi* of Fleſhy Fibers, which lie parallel to each other, *&c.* of which enough may be ſeen, with a full Deſcription of each ſort of Muſcles in the Original Authors: I ſhall omit the Repetition here, and only take Notice of it's Fabrick, as far as relates to my Hypotheſis.

Every

Of the Structure of a Muſcle.

Every Muſcle is endowed with oppoſite Tendons, which are compoſed of ſeveral *Faſciculi* of Fibers, lying parallel to each other.

Theſe Fibers being ſtrictly joyned together, compoſe a ſtrong, tenacious and firm Tendon; but being ſeparated one from another, are more fragile, and ſubject to be eaſily broke, and pulled in pieces; they are continued from each Tendon to it's oppoſite.

The Interſtices of the Fibers thus ſeparated, are filled with the Branches and Extremities of Veſſels, the major part of which are Sanguiferous; ſo that the Fibers continued through the Belly of a Muſcle, being obſcured

obſcured by the colour of the Blood, ſeem to degenerate from the Tendinous Fibers, and therefore are called Fleſhy.

Theſe Fibers as they are continued from each oppoſite Tendon, ſo alſo there is a continued Cavity from one end of Every Fiber to the other; which being partitioned by ſeveral tranſverſe and perforated Membranes, every Fiber, according to Dr. *Croone*, reſembles a continued Series of Bladders opening one into another.

The formal cauſe of the contraction of a Muſcle.

By an Intumeſcence of theſe Fibers, they are contracted in length; and by a Contraction of their Longitude, each Tendon is drawn nearer

nearer to its oppoſite; which is the formal cauſe of Muſcular Motion, as far as can be made evident by *Autopſie:* This is ſo unanimouſly aſſented to, and ſo apparent to the naked Eye, that it requires no further proof.

As for the Efficient Cauſes of Muſcular Motion; before they can be ſufficiently ſhewn, we muſt enquire how many ſorts of Veſſels are implanted into each Muſcle, which according to Anatomiſts are Four, *Nerves*, *Arteries*, *Veins* and *Lymphæducts*; the *Nerves* and *Arteries* furniſh the Muſcles with Spirits and Blood; the *Veins* and *Lymphæducts*, carry back

Veſſels implanted into a Muſcle.

back the ſuperfluity of Blood and Lympha.

The Branches of all theſe Veſſels are minutely diſtributed through the whole Muſcle, and by an intermixture and texture of the moſt Minute and Subtile Branches of the ſame, is formed that Subſtance, which fills up the Interſtices of the Fibers, and which denominates the whole Belly of a Muſcle Fleſhy. The colour of theſe Veſſels, as of all others, is without doubt White, but by the Contents of the Sanguiferous Veſſels, the whole Belly of a Muſcle is coloured Red. *Their diſtribution.*

The Terminations of theſe Veſſels are ſo minute and ſmall, ſo brittle, and ſubject to be broke,

broke, that it's as difficult to trace, and find their Terminations, and Insertions, as to divide a Hair into an Hundred Parts; and though many things are made visible by the help of Microscopes, which are otherwise too subtile to be discerned and discovered by the naked Eye; yet I am not without Reason perswaded, that the terminations of these Vessels, cannot be perceived by the help of a Microscope.

Some indeed, whatever they think is probable, lest it should not be credited, presently strenuously affirm, they saw it with their Microscopes; and so easily impose on those that less inquire after truth themselves, but take it on trust from others; and perhaps

perhaps prevent thoſe not ſo exquiſitely skill'd in Microſcopes, from making any further ſearch after truth. I ſhall not here ſay, that what I propoſe concerning the Terminations of theſe Veſſels, was ſeen with any Microſcope, but ſhall declare my Opinion in this Matter, too ſubtile for any Microſcope but Reaſon.

And terminations in ſmall Glands.

It being impoſſible for any one to underſtand the true Reaſon of Muſcular Motion, unleſs firſt acquainted with the diſtribution of theſe Veſſels, and their Contents; firſt, I conceive, that as the Nerves, Arteries and Veins, are all diſtributed through a Muſcle, ſo it is but Reaſonable to conclude, that

that their minute and ſubtile twigs are all, before they terminate, interwoven and mixed with one another: And if ſo, it will not be abſurd to imagine, that they all end, as it were, in ſmall and *Diminutive Glands*: And if the ends of the Veſſels be ſo ſmall, that their terminations cannot be perceived by a Microſcope, theſe *Glandules* compoſed of the Inviſible ends of the aforeſaid Veſſels, muſt needs be very ſmall and fine, and conſequently may not be perceived by the help of extraordinary Microſcopes.

From theſe *Glandules* thus formed, are derived ſhort *Ducts* or Paſſages, for the conveyance of a ſubtile Liquor, out of the aforeſaid *Glandules*, into the Cavities

Cavities of the Carnous Fibers. This Paſſage very likely, may be compoſed of the external Arterial Coat. Into the Cavity of the Carnous Fibers, beſides theſe *Ducts*, the twigs of the *Lymphæducts* are alſo inſerted, to carry back a ſuperfluous *Lympha.*

If any one thinks it improper or abſurd to aſſert, that theſe Veſſels do thus terminate, as if it were in ſmall *Glandules*; let him but conſider what a Gland is, and how it is compoſed, and he will not think the Concluſion irrational. *Proved.*

For a Gland is nothing elſe, but a Compoſition of an Infinite Number of ſmall and diminutive *What a Gland is.*

minutive Veſſels, ſeveral, and moſt of which, have Communication one with another; which Gland ſo compoſed, is as a Store-houſe to receive and contain a certain Liquor, till neceſſity requires, or its quantity cauſes an excluſion of it: And this ſeems plainly to be favour'd by Dr. *Ridley*, when he ſays, that the whole Body is a continuity of Veſſels, *ad infinitum*. Now, if a Gland conſiſts of an infinite Number of ſmall Veſſels; and if the Branches of Nerves, Veins and Arteries be divided before they terminate, into an innumerable number of moſt inviſible twigs, as is moſt certain; when from one twig of each ſort, is derived a vaſt number, and

and all these so derived, are mixed and interwoven one with another; why may we not say, at least Metaphorically, since they in their Distributions imitate the Composition of Glands, that they terminate in small Glandules.

Some perhaps will ask, how must we discover these Glands? *Malpigius* hath observed the Liver to be composed of Clusters of Glands, hanging at the Extremities of the larger Vessels, like so many Bunches of Grapes; and the Glands in other parts are apparent; but in a Muscle we can discern no such things; for it, especially when boiled, parts into distinct Carnous Fibers.

To which I Anſwer, That thoſe Glands are nothing elſe but a Compoſition of the ends of importing and exporting Veſſels; and the Reaſon why we cannot diſcern the ſame in a Muſcle is this, becauſe the Extremities of the Veſſels are ſo fine, and conſequently ſo brittle, and are contained in the Interſtices of ſo ſtrong and firm Fibers; that whenever we endeavour a ſeparation of the Fibers, the Glandules are torn away from the Veſſels from which they are derived; whereas the Fibers which run tranſverſe the Liver eaſily crumble away, being much more weak and leſs Numerous.

Why they cannot be diſcerned.

The

The Reaſon why the Muſcular Fibers are ſo much ſtronger, than thoſe that run through the Liver, is apparent enough, *Viz.* becauſe the former are the Inſtruments of Motion, and conſequently there lies a greater ſtreſs on them, than on the latter, which ſerve to make the Part a little more compact, and to keep the outward Coat from being looſe upon it's Circumference.

Now becauſe it is impoſſible to ſeparate and remove theſe Muſcular Fibers, ſo as to leave the Sanguiferous Veſſels as entire as would be requiſite for the exact and certain diſcovery of their Terminations; and becauſe it is certain, that theſe Veſſels are divided, and ſubdi-

vided *ad minimum*; that they are interwoven one with another, and that a Gland is nothing elſe, but a Compoſition of Veſſels; we may rationally conclude they all Terminate in *Diminutive Glands*.

The Nerves, Veins and Arteries, compoſing and ending in theſe Glands; I ſhall next Enquire, to what end they do all thus meet together.

The Uſe of the Nerves.

The Uſe of the Nerves in theſe is the ſame as in other Parts, *Viz.* to conveigh a Spirituo-ſaline Liquor from the Brain: Which Spirits being Volatile and apt to Ferment, when mixed with a Liquor of a contrary Nature, are continually ſent by the Syſtole of the

the Brain into all the Muſcles of the Body, and being laid down forcibly in the aforeſaid *Diminutive Glands*, do there meet with Arterious Blood driven in by every Contraction of the Heart: Which two Liquors ſtrongly fermenting together, the Animal Spirits do by an Attrition Subtiliſe, Attenuate, and Rarifie thoſe Particles of the *Succus Nutritius* ſupplyed from the Maſs of Blood; by which Means their own are much dulled, and become leſs Active for the future; and by a Mixture of theſe Animal Spirits, with the rarified *Succus Nutritius*, reſults a *Liquor* Different from, and of a middle State betwixt, the

And Arteries inſerted in the Glands.

To prepare a Liquor different from the Spirits or Succus.

Animal Spirits, and the ſaid unfermented *Succus Nutritius*; which *Liquor* thus compounded and prepared, is driven by a Succeſſion of Matter through its proper *Paſſages*, into the Cavities of the *Fibrous Cells*, the remaining and more crude Part of the *Succus Nutritius* being received together with the Blood, and carried back to the Heart.

The Uſe of it. This *Liquor* after this manner conveighed to the Cavities of the Fibers, does as it paſſeth, and is thruſt through according to the continual Laws of Circulation, give nouriſhment to the Parts, and is thence received by the *Lymphæducts*.

Thus

Thus I conceive it is continually prepared in the *Glandules*, and Circulates through the Carnous Fibers of all the parts of the Body, whilſt Motion ceaſeth in a moderate quantity; ſo that the *Lymphæducts* are capable of receiving it, and thereby prevent the Præternatural Repletion of the Fibers.

To prove what I have hitherto ſaid, beſides the *Veriſimilitude* the thing carries with it, I could bring many Arguments to illuſtrate, and to make it appear more Plauſible and Evident; but for Brevities ſake, and to prevent unneceſſary Repetition, I ſhall omit 'em here, becauſe they are to be Mentioned hereafter.

I have given a breif Account of the Structure of a Muſcle, as far as relates to my Hypotheſis, and the Uſe of the Parts, as they ſerve to Nutrition. I now proceed to the Efficient Cauſes of Muſcular Motion, both Voluntary, and Involuntary; and firſt of the Reaſon of Voluntary Motion.

That Voluntary Motion does depend upon the Dictates of the Soul, and is the Reſult of it's Faculties, but more immediately of our Appetite, is ſufficiently Evinced; becauſe it's inſtantly perform'd according to our Will. Where the Soul is lodged; how, and after what Manner, it Operates; and what it is, is moſt difficult to determine

mine, and is not designed for our present enquiry: But as it comes under the Consideration of the Brain, and it's appendages; I shall defer my Thoughts of that, till I have a further Opportunity.

In the mean time, That neither the Soul, nor any of it's Faculties are the immediate Causes of Muscular Motion, but Operate by the Mediation of the Animal Spirits, will appear from what follows concerning the Reason of Voluntary Motion: And that the Office of the Will, is only to open and shut the Pores of the Brain, by an Organical Motion, as necessity requires, what this Motion is, and how it is performed, and after what manner

the Dictates of the Soul and of its Faculties are put in Action, is referved for its proper Seat.

After what manner ſoever the Soul exerts it's Faculties, and directs that Subtile Matter the Animal Spirits (which is ſent through the Branches of the Nerves, in greater or leſs quatities according to our Appetite) to this or that Part; it is allowed, that when our Body ceaſeth from Motion, and all our Voluntary Faculties are at quiet, the Pores and Paſſages of the Brain leading to the Inſtruments of Voluntary Motion are locked or cloſed up: And then I ſuppoſe, that the Spirits moderately flowing into each Muſcle, do prepare ſo much of the *Subtile Liquor* aforemention'd

as

as is ſufficient to Nouriſh the Parts as it paſſeth through 'em.

But when the Pores of the Brain are opened, and unlocked, the Animals Spirits forced by a continual Succeſſion of Matter, flow into all the Branches of the Nerves more plentifully, and being laid down in the *Glandules*, raiſe a ſtronger Fermentation; by which means a greater quantity of the Subtile *Liquor* is prepared, and forced into the fleſhy Fibers more copiouſly and rather faſter than it can be received and evacuated by the Lymphæducts; ſo that the Fibers being all equally ſwelled with its quantity, conſequently Contract the Muſcles; which

The Reaſon of Tonick Motion

which is the Cauſe of a Tonick Motion.

When theſe Animal Spirits, are by a preſſure and Syſtole of the Brain and ſucceeding Spirits, ſent yet more plentifully into the Nervous Channels leading to the Muſcles to be Contracted, than into thoſe which are in *Motu Tonico*, or into the Antagoniſts (the Paſſages and Pores leading to thoſe Nerves being yet more expanded and opened) there is a greater quantity of the Subtile Liquor prepared in the *Glandules*, and thruſt out into the Carnous Fibers; and their Cells being more ſwelled and dilated, conſequently there follows ſtronger and more violent Contractions of the Muſcles; whence

whence proceeds Local Motion.

By the Syſtole of the Brain I don't mean any other Motion than what proceeds from the Pulſation of the Arteries diſtributed through that Part. That this motion only proceeds from the Pulſation of the Arteries implies, that it is ſtronger, & drives the Spirits through the Brain into the Nerves with greater force than if it were really the Motion of the Brain it ſelf; the Heart from whence the Pulſation of the Arteries proceeds, being a ſtronger and more compact Part as to its Subſtance, than the Brain.

If it be asked, why this *Subtile Liquor* is not more eaſily forced into the Venous Ducts, than into thoſe that lead to the Fi-

Fibrous Cells, becauſe the former are larger?

I Anſwer, That the Venous Ducts are ſo proportioned, that they might not be capable of receiving all that is laid down by the Nerves and Arteries; on purpoſe, that ſome Subtile Parts might be continually driven into the Fibrous Cells; and when by a more copious Influx of Animal Spirits, a ſtronger Fermention is raiſed in the *Glandules*; preſently the Contents ſwell up and are expanded; ſo that the Veins being not able to receive them as before, more of that *Liquor* is not only ſubtilized, but forced into the Fibers.

As ſoon as, according to our Appetite, the Pores of the Brain, which conveigh Spirits to the Nerves

Nerves leading to the Contracted Muſcles, are ſhut more cloſely up again, and leave of to be dilated; the Animal Spirits ceaſe to flow more into the Muſculous *Glandules*, than are required to Subtilize, and prepare a ſufficient quantity of Nouriſhment for the Fibers (as in the Antagoniſt,) then preſently the Contraction ceaſeth to be carried on, and the Superfluous *Liquor* heaped up in the Fibers, is evacuated by the Lymphæducts.

Here perhaps, becauſe I ſaid in the foregoing Paragraph; the *Liquor* heaped up in the Fibers is Evacuated by the Lymphæducts; it may be a Queſtion whether this *Liquor* does all the time a Muſcle is Contracted, conſtantly

Objections Anſwered.

ly flow through theſe Cells into the Lymphæducts; or whether it remains in the Cells till Motion is to ceaſe, and is not evacuated by the ſaid Ducts till then.

I ſay it does continually run of by the Lymphæducts, conſtantly a'l the time a Muſcle is Contracted: Otherwiſe ſince as long as Spirits are directed, in a competent quantity, to the Contracted Muſcles, to keep up the Dilation of the Fibers; they would preſently be incapable of receiving it, and it muſt needs Regurgitate as it was prepared, and in a great Meaſure diſturb Circulation. But to prevent many abſurd Conſequences, if it ſhould remain in the Cells ſo long; I affirm, that it is conſtantly

ſtantly forced forward, by a Succeſſion of Matter ; and as it is forced into, and Circulates through, theſe Cells, in greater or leſs quantities, ſo Contractions are ſtronger or weaker or not at all, the Fibrous Cells being accordingly Diſtended, Dilated and Contracted in Longitude; and when according to our Appetite, this *Liquor* ceaſeth to flow into the Fibers in ſo great a quantity as to Contract the Muſcle; that matter which before dilated the Fibers, is Evacuated, as being Superfluous Nouriſhment, ſo that for the future it runs through in a moderate quantity as before Contraction, till their Repletion is again renued to Reiterate Motion.

If

If it be asked, why this *Liquor* is not as eaſily forced backwards out of the Fibrous Cells into the *Glandules* from whence it came, as into the Lymphæducts; and ſo think there would be no need for Lymphæducts.

I anſwer, That if there be no Valve at the inward Orifice of every *Duct*, to hinder its reflux; (which would be no abſurdity to conclude; for we ſee always upon the like occaſion, Nature hath furniſh'd ſuch Places with Valves;) yet I ſay, if there were none, the direct Motion of ſubſequent Matter from the *Glandules*, would ſufficiently hinder the reflux of it; and ſince its reflux is oppoſed, by new matter forced ſucceſſively

ly after it; and since according to the course of Circulation, the Matter driven into the Lymphæducts before it, will give way for its expulsion, it would be more reasonable to imagine, that the matter contained in the Fibers is evacuated *qua datur porta*, rather than *qua non datur*; for when we design the Relaxation of a Muscle, though the Liquor successively sent from the *Glands*, does not press forwards altogether as forcibly, and in as great Quantities, as whilst Contraction is continued; yet it follows moderately, so as to oppose the Retrocession of any thing; I mean moderately, as to its quantity; for the continual violent concourse of the Animal Spirits,

Spirits, and Arterial Blood, drive it then into the Fibers, almoſt as violently as when the Muſcle is contracted.

The Uſe of the Lymphæducts.

That theſe *Lymphæducts* do thus receive this Subtile Liquor; and that for that end they are inſerted into the Fibrous Cells, I am perſwaded; becauſe it cannot otherwiſe be underſtood, how the Matter that ſtuffs them up, and cauſes Contraction, could be drawn out again, without a Retroceſſion through the ſame Channels by which it was brought in: And though the moſt Learned and Famous Dr. *Willis*, Dr. *Ridley* and others, do allow a Retroceſſion, yet ſince it contradicts the courſe of Circulation,

tion, we muſt either deny Circulation, or reject their Opinions.

Beſides, I cannot conceive, what other occaſion there is for Lymphæducts in a Muſcle; ſince whatever is brought by the Arteries, might as well be returned by the Veins, as by two ſorts of Veſſels: But for as much as Nature hath made nothing in vain, and ſince there is ſo great neceſſity, that they ſhould be inſerted into the Cells, I think it not irrational nor abſurd, to conclude they were deſigned for the afore-mentioned end.

The Nature of the Liquor conſider'd, and the manner of its preparation.

That we may underſtand a little better the Nature of this Liquor, which

which we have ſo often mentioned; let us conſider a little more fully, how that Fermentation is carried on in the ſaid *Glandules*. It's commonly known, that when a Ferment is put to a Maſs, whether Liquid, or of a ſolid conſiſtence, whatever is the nature of the Ferment, it, according to its power, always endeavours to render whatever comes within the Sphære of its Activity, as like it as poſſible. So in theſe *Glandules*, the Animal Spirits fermenting with the Arterial Juice, and the Nature of 'em being, according to Dr. *Willis* and *Diemerbroeck*, *Spirituo-Saline*, compoſed of Volitile Salt and Sulphur, they by Reaſon of their abſolute Quality,

By Fermentation.

Quality, more readily mix with the crude Sulphureo-ſaline Particles of the *Nutricious Arterial Juice*; and as they are more or leſs in quantity, ſo they exalt and carry forth into a Flux, more or leſs of that Crude Sulphureo-ſaline Maſs; which, being by Fermentation ſubtilized, is diluted with a ſufficient quantity of *Lympha*, or the watry part of the *Serum* of the Blood, and the *Liquor* reſulting from that Compoſition, is thruſt out into the Fibrous Cells.

That this *Lympha* might be thin enough to dilute the ſaid *Liquor* ſufficiently, it is much attenuated in that Fermentation.

That

That there is ſuch a Fermentation, that the Nerves are inſerted into the *Glandules*, and lay down Animal Spirits, as the Principal Cauſe of that Fermentation; that the Arteries lay down Blood together, with the aforemention'd *Juice*, and that in thoſe *Glands*, a ſubtile *Liquor* is prepared, being compoſed of Animal Spirits, and the moſt rarified parts of the ſaid *Succus*; that neither the Arterial Juice, nor the Animal Spirits ſimply can cauſe the Contraction of a Muſcle; but furthermore, that it is neceſſary that this Subtile *Liquor* ſhould be ſo prepared and compoſed, as being capable to enter into the Fibers, and to contract the Muſcle, is ſufficiently

Proved.

ciently apparent from what hath been ſaid, and will more clearly be evinced by what follows.

And firſt, If there be a Communication of theſe Veſſels, as certainly there is; then it muſt needs follow, that there is a commixture of their Contents; if there be a commixture of their Contents, then there is a Fermentation, and in that Fermentation it muſt needs follow, that the Animal Spirits will according to their Energie and Activity Subtilize and Attenuate the Crudeſt Parts of the *Arterial juice*: By a mutual Fermentation there muſt needs be implyed an intimate Commixture, and the Reſult of that Commixture muſt needs be different from the Animal Spirits, or *Arterial juice*

ſimply before they are mixed; ſo that the *Liquor*, reſulting from the Mixture of 'em, may be properly called a *Subtile Liquor*: And accordingly as the Animal Spirits are more or leſs in quantity, to mix with the *Arterial juice*, more or leſs will be prepared and thruſt out into the Fibrous Cells, and conſequently the Fibrous Cells muſt be more or leſs Tumified, and the Muſcle Contracted, as more or leſs Spirits are laid down in the *Glandules*. So that all I have to Prove is, That neither the *Arterial juice*, nor the *Animal Spirits* can cauſe the Contraction of a Muſcle, and then it will follow conſequently, that there is a Communication of theſe Veſſels, and for that end, in the aforeſaid *Glandules*. It

It hath often been found, that an *Atrophea* of the Parts will follow the Relaxation; & a Palſie the Abſciſſion, or Ligature of the Nerves leading to thoſe Parts: Which ſufficiently ſhews, that the *Arterial juice* it ſelf, cannot cauſe the Contraction of a Muſcle, without the aſſiſtance of the Animal Spirits; becauſe when the Animal Spirits ceaſe to flow into the *Glandules*, for want of a dew Fermentation, to Subtilize and Prepare a ſufficient quantity of the *Arterial juice*, the Carnous Fibers are not only deprived of neceſſary Recruits, and Alimental refreſhment, ſo that they muſt needs waſte away and grow Languid, but alſo for want of a

The Arterial juice *ſimply cannot cauſe the Contraction of a Muſcle.*

ſufficient quantity of the Subtile *Liquor*, to diſtend the Fibrous Cells, they become deſtitute of Motion.

That the Animal Spirits ſimply, cannot cauſe the Contraction of a Muſcle is proved; becauſe by a Ligature on the Deſcending Trunk of the Aorta, the Inferior Parts become deſtitute of Motion: For tho' the Influx of the Animal Spirits, be not hindered; yet for want of *Arterial juice*, the matter requiſite for the Compoſition of this *Subtile Liquor*, is not laid down in the *Glandules*; and the Muſcles, the Inſtruments of Motion, cannot Contract without an Efficient cauſe.

Nor the Animal Spirits.

From

From what is contained in these two Paragraphs, it appears; that neither the *Animal Spirits*, nor the *Arterial juice*, simply can cause the Contraction of a Muscle; because when the Animal Spirits are hindered to flow into the *Glandules*, to Subtilize and prepare the *Arterial juice*, it is not thin enough to be driven out into the Fibers: And tho' when the Influx of the *Arterial juice* is hindered, the Spirits are permitted to flow in; yet by Reason of the small quantity of 'em, they run through the Fibers without distending 'em.

That this *Arterial juice* ought not, nay cannot, pass into the Fibrous Cells, till subtilized and prepared by

Because the Arterial juice *cannot pass into the Fibers till prepar'd by the Spirits.*

by the Fermentation in the *Glandules*, is Plain; becauſe if it could, they wou'd be ſtuffed up with the quantity of it, driven in by the continual courſe of Circulation, ſo as to Contract the Muſcle againſt our Will; which is otherwiſe.

Now ſince the *Arterial juice* cannot paſs into the Fibers till Subtilized; and ſince the *Animal Spirits* are not enough in quantity; moreover ſince neither of 'em, ſimply are capable of Contracting the Fibers, and if either be obſtructed the Action is aboliſhed; I ſay ſince it is an Action, that depends upon the mutual Aſſiſtance of each; it is apparent, That it muſt be performed by a *Liquor* reſulting from a Mixture of both.

And

And then we must of Necessity allow a Communication of these Vessels; else there could be no mixture of their contents; and the *Arterial juice* must be prepared before it can be forced into the Fibers, for the Reasons beforementioned: to which end it will be necessary that the Vessels terminate in the *Glandules*, That their Contents may be mixed, and that this Subtile *Liquor* (resulting from a Mutual conflict of the Animal Spirits subtilizing the cruder *Arterial juice* by Fermentation, in greater or less quantities accordingly as the Spirits are laid down by the Nerves) may be prepared and made ready to be driven into the Fibers.

To promote the Fermentation, and the Preparation of this Subtile *Liquor*, the forcible influx of the Animal Spirits, and of the Arterial Blood much conduce: For be the Temper of the *Arterial juice* and of the *Animal Spirits* never ſo good, unleſs they are driven violently one againſt another, there would be required a longer time before they could be ſo mixed and fermented as they ought, but the ſucceſſion of new Matter admitting no long delay, it is requiſite that they ſhould be thus forcibly driven in together; to the end that the Spirits might be diffuſed through the whole Maſs ſooner, and that their Minute Particles, ſtriking more violently againſt the fixed and compacted

compacted Particles of the Blood, might more immediately break and ſeparate the ſtrict Union of its Parts; and by a violent Fermentation, ſufficiently diſſolve and volatilize 'em, in ſo ſhort a time as the Continual Pulſations of ſucceeding Humors admit.

The violent concourſe of the Blood and Spirits, do not only promote this Fermentation, and the ſeparation of the Subtile *Liquor*, but alſo ſucceſſively force the Matter prepared and ſeparated into the fleſhy Fibers: This is ſo highly Probable, that it needs no Arguments to make it more Evident; it being the unavoidable conſequence of a continual Circulation.

Now I have given the Reaſons of Voluntary Motion, and the Efficient Cauſes of the Contraction of a Muſcle; it will be eaſie to unfould the Reaſon of Involuntary Motion. That Voluntary Motion depends upon the Will is manifeſt; and that Involuntary Motion is not at all Subject to it, but is performed not only without the Dictates of our Appetite but againſt 'em, is ſo evident, that it would be ſuperfluous and uſeleſs to diſpute it: I ſhall only ſhew how it is performed, which is indeed a little more obſcure.

The Reaſon of Involuntary Motion.

As Voluntary Motion is perform'd, for as much as the Pores of the Brain

Brain are dilated according to our Appetite, ſo that the Animal Spirits flow more plentifully into the *Glandules*, and prepare a ſufficient quantity of the Subtile *Liquor* to diſtend the Fibers as it paſſes through 'em; ſo thoſe Pores, which lead to the Nerves ſerving to Involuntary Motion, are proportioned in ſuch a manner, that they continually conveigh Animal Spirits in a ſufficient quantity to cauſe a perpetual Motion.

Theſe Pores being ſo proportioned, there is no need that they ſhou'd have ſuch an Organick Motion as thoſe ſerving to the Inſtruments of Voluntary Motion; becauſe ſince they are proportioned ſo, as to carry Spirits in a competent quantity, there

is

is no neceſſity that they ſhould be either Dilated or Contracted.

Proved.

To Prove that theſe Pores do lay down a competent Quantity of Spirits to be carried to the *Glands*, I need not bring many Arguments; for its plain and evident to all Practitioners in Phyſick, that when the Spirits are too much carried forth, and exalted, as in a *Diary* Fever, the Pulſe is ſtrong and vehement, and by a too great exagitation of them, it becomes more quick and frequent; it is alſo Evident, that when the Animal Spirits are depreſſed, the Pulſe is Weak, Slow and Rare, as moſt commonly in Women, ſubject to Hyſterick Fits; and when

when the Spirits by an Acute or Cronick Diſtemper are worn out, and almoſt ſpent, the Pulſe is either *Vermiculans*, *Formicans* or *Tremens*; which are ſigns that Nature is almoſt ſpent, and ready to yield to the Diſtemper. I ſay this is evident enough; it is then beyond Contradiction, that a healthful Pulſe depends upon a moderate Quantity of Animal Spirits, and that they continually flow into thoſe Nerves leading to the Inſtruments of Involuntary Motion; and as their Quantity varies, ſo more or leſs of the Subtile *Liquor* is prepared to diſtend the Fibers of thoſe Muſcles.

When the Spirits are weak, or almoſt ſpent, there muſt needs flow a leſs quantity into the

the *Glandules*; and when they are exalted, a greater; and if Extremes either fruſtrate Natural, or cauſe Preternatural Effects, we may not only conclude, that Natural Actions are performed by a moderate Quantity, but from hence we may bring good Arguments for a further proof and confirmation of my Hypotheſis about Voluntary Motion.

How it comes to paſs, that the Syſtole of the Heart, is interrupted with ſuch frequent Diaſtoles.

Since I have ſaid, that the Spirits, by Reaſon of a particular Proportion of the Pores, flow continually in a juſt Quantity; and that theſe Pores are not ſubject to be Dilated or Contracted according to our Appetite; it remains, that I ſhould

ſhould ſhew how it comes to paſs, that the Syſtole of the Heart is interrupted with ſuch conſtant Diaſtoles; whereas, when the Pores ſerving to Voluntary Contractions are open, ſo as to convey a ſufficient quantity of Spirits, the Motion is continual and without Intermiſſion.

The Reaſon of the Difference will eaſily appear, if we do but take Notice, how when a Vein is opened, the Blood runs out continually, without ceaſing or intermiſſion; but if an Artery be opened, it guſhes out with Intermiſſions anſwerable to the Diaſtoles of the Heart: becauſe the Veins are always as a common Ciſtern, diſtended with Blood; and before they can be emptied

emptied with a ſmall Orifice, they are filled by the Extremities; but the Blood being continually received by the Extremities of the Veins, and thoſe Extremities being furniſhed with Valves, to hinder it from Regurgitation; the Arteries are always kept more lank and empty, and are not as the Veins diſtended with Superfluous Blood: So that it only flows out of them, when they are diſtended upon violent Syſtoles of the Heart.

In like manner, that part of the Brain that furniſhes the Nerves ſerving to Voluntary Motion with Spirits, is like a common Ciſtern full of Spirits; and when Vent is given (the Pores being opened according

to

to our Appetite,) the Spirits are thruſt forth in one conſtant courſe: But the Muſcles ſerving to Involuntary Motion, being in continual Action, do ſo drain their Store-houſe, as to keep it more flaccid and empty; ſo that the Animal Spirits, as they are prepared, are continually waved through their proper Pores; and as one Wave follows another, ſo one Contraction perpetually ſucceeds, the *Subtile Liquor* being according to the ſame Rules prepared in the *Glands*, and thruſt out through the Fibers.

Some of the Muſcles deſigned for Involuntary Motion, are, in ſome meaſure, ſubject to our Will, ſo that it lies in our power to

to retardate or quicken the ſucceſſion of their Contractions, but not totally to obſtruct or hinder them; as the Muſcles ſerving to Reſpiration: The Reaſon of which is this.

Why the Muſcles ſerving to Reſpiration, are ſubject in ſome meaſure to our Appetite.

The Pores of the Brain leading to the Nerves, which convey Spirits to theſe Muſcles, are ſo framed, that they carry Spirits to them, as to the other Muſcles ſerving to Involuntary Motion, in a competent Quantity; but theſe Pores differ from thoſe, for as much as theſe have ſuch an Organick Motion, as to contract or dilate according to our Appetite, we can by a conſtriction cloſe up theſe, ſo as to deny a Paſſage for

for Animal Spirits, ſufficient to prepare a quantity of the *Subtile Liquor* to cauſe due Contractions of the Muſcles; till by degrees they increaſe to ſuch a great Quantity, and diſtend their Receptacles ſo long, that thoſe are no longer capable of receiving more; till that force which drives them violently into the Receptacles overcomes the conſtrictive Faculty of the Pores; and then the Spirits, againſt our Will, break forth, and flow violently into the Muſculous *Glands*.

It is eaſily noted, that after we have holden our Breath a long time, the firſt Contractions are as if Two or Three were joyned together without intermiſſion: I mean ſo long continued;

nued; which is ſufficient to prove what I have ſaid of the Muſcles ſerving to Reſpiration.

For when by a Conſtriction of the Pores, the Spirits which ought to flow out, are kept in, and heaped up in their Receptacle, and Two or Three Contractions are by that means hindered, that Receptacle becomes like a common Ciſtern; and as ſoon as the Pores are forced open, the Spirits running out, cauſe long continued Contractions, till that ſtore is ſpent, and then they wave through, as before the Interruption.

What I have hitherto ſaid, might be ſufficient to prove my Hypotheſis reaſonable; but to illuſtrate

illuſtrate it a little more, I ſhall explain ſome of the *Phænomena* about Muſcular Motion, and give ſufficient Reaſons for them agreeable to my Hypotheſis.

Why old People are ſubject to a trembling of their Head or Hands.

Common Experience tells us, that Old People, whoſe Spirits are flat and weak, are moſt uſually ſubject to a Trembling of their Head or Hands; the Reaſon of which is this: The Fermentation in the *Glandules* is too low and weak, and doth not ſubtilize a ſufficient Quantity of the ſaid Liquor, to keep the Muſcles in a conſtant Motion: The Reaſon why a ſufficient Quantity of Liquor is not prepared, is plain; for though their

their Appetite and Desire is strong enough, and endeavours to open and dilate the Pores of the Brain; yet when the Spirits are weak, it's a sign few are separated from the Blood; and if few be separated, they cannot flow plentifully into the Nerves, be the Pores never so wide.

This confirms the Reason I have given, why the Systole of the Heart is interrupted with constant Diastoles: For the Store-house which supplies it, is always kept empty, by reason of the constant efflux of Spirits; and in Old People, the Store-house which furnishes the Nerves serving to Voluntary Motion with Spirits, is kept empty; because few Spirits are sepa-

ſeparated from the Blood; and as they are ſeparated, they are continually ſpent by a conſtant diſtribution of them, to prepare Nouriſhment in the Muſculous Glands: So that when the Pores are opened wider for Voluntary Motion, for want of a ſufficient Stock, they cannot flow out in a conſtant and equal proportion, but as they are ſeparated, they wave through thoſe Pores that are moſt ready to receive them. The Motion indeed is not interrupted with ſuch perfect Intermiſſions, becauſe this Store-houſe is not ſo clearly drein'd; but there is a perfect Remiſſion, becauſe the Stock is not ſo copious as in Young and Luſty People to yield conſtant Supplies.

More-

Moreover, when the Spirits are weak, its a ſign that the Blood is much depauperated, and declines from its Natural ſtate; and then there is more need for ſtrong Spirits to raiſe the Fermentation in the Glands, and to ſubtilize the Liquor: Upon which account, when the Spirits are weak, the Diſadvantage muſt needs be the greater.

Hence may be deduced a Reaſon, why when our Spirits are low, and almoſt ſpent, though our Appetite be ſtrong, we cannot perform ſtrong Actions.

From hence it may be proved; that there is ſomething prepared in theſe *Glands* by the Animal Spirits, which is incapable of entring

entring into the Fibers till prepared: For whether the Spirits be weak or ſtrong, there is a ſufficient quantity of *Arterial juice* laid down in the *Glands*, tho' its not made capable of paſſing into the Fibers, but as it is prepared, accordingly as the Spirits are more or leſs in quantity, ſtronger or weaker.

Another Phænomenon Explained.

I have known Women, who ſeemed healthful, and of a Sanguine Complexion, whoſe Hands wou'd, when they were about any Moderate Exerciſe, Tremble as if Paralytick: For the Maſs of Blood being a little more than uſually depraved, and degenerated from its Balſamick and Sulphureous, into a more crude and Phlegmatick

State, was unapt for Fermentation; ſo that the Animal Spirits being not able eaſily to prepare a ſufficient quantity of the aforeſaid Subtile *Liquor*, to keep the Muſcle in a conſtant Motion, were forced to do it by an unequal Influx: juſt as an Horſe, ſet to draw too great a Burthen, is forced by many reiterated draughts to get it forwards.

A Third.

Mr. *Cowper* Mentions an Experiment, how by an Injection of Water into the Crural Arterie, the Muſcles of the Legs renue their Contractions. From this he would infer, that Muſcular Motion is performed by the Blood as a Pondus; but tho' his *Myotomia* Argues, it came from an Inquiſitive Author, yet

I

I rather am fully perſwaded, that the Blood does not Act as a Pondus, becauſe this Experiment pleads againſt it; but to avoid a long diſpute, I ſhall only give the Reaſon of the *Phænomenon*.

Before the Injection of this Water, the Branches of the Arteries are full of Blood, and *Arterial juice*; and when by the mixture of the Water with this *juice*, it is attenuated and driven into the *Glands*, faſter than it can be received by the Venous Channels, the moſt Subtile Part is by the force of Injection, ſtrained into the Fibers and diſtends 'em ſo as to Contract the Muſcle.

Perhaps here it will be objected that if the Water can thus paſs through into the Fibers,

what need is there that the Nerves ſhould lay down their contents in the *Glandules*.

I anſwer, that the Water is thin and apter to paſs through thoſe *Ducts* than the *Arterial juice*, which is thick and viſcid; wherefore it is neceſſary, that the *Nerves* ſhould lay down their contents there, to Attenuate and Rarifie this Thick *juice*.

A Fourth. I have ſeen People inclining to a Dropſie, whoſe Blood and Serum was much diluted, could move much more nimbly, tho' more feebly, than ſome of a healthful Conſtitution, whoſe Blood and this *Arterial juice* was thicker and not ſo much diluted; which doth plainly ſhew

ſhew, that the thinner the Blood is, and the more diluted the Nutritious juice, the leſs quantity of Spirits is required to ſubtilize it, and make it capable of paſſing into the Fibers.

A Fifth.

It may eaſily be obſerved, that thoſe People whoſe Spirits are ſtrong, and their *Arterial juice* very thin, are Nimble; but the Contractions of their Muſcles are not ſo durable, as of thoſe, whoſe Serum is of a thicker Conſiſtence: For tho' in the former more of the Subtile *Liquor* is prepared, yet by Reaſon of its Tenuity it's ſooner receiv'd, and carried off by the *Lymphæducts*; which makes the Contraction ſhorter,

A Sixth. Thoſe whoſe Blood abounds with fixed Salts & Phlegmatick Humours, which too much dull and reſiſt the Activity of the Animal Spirits, are always ſlow and unapt for Motion; whereas, if the Blood Acted as a Pondus, they muſt be more nimble and ſtrong; becauſe the thicker the Blood is the heavier would be the Pondus.

As Muſcular Motion is many ways vitiated, by the fault of the *Arterial juice*, or of the Spirits, and conſequently by the Diſtemperature of this ſubtile *Liquor*; ſo it is very often depraved, and accordingly as the Maſs of Blood degenerates from

from its genuine and proper Nature, are produced various Diſeaſes or Symptoms of Diſeaſes: *viz.* Cramps, Convulſions, Palpitation of the Heart, Leaping of the Tendons in Fevers, *&c.* for a farther illuſtration of my Hypotheſis, before I conclude, I will give the Reaſons of theſe *Phonomæna.*

The Reaſons of Convulſions.

When by an Abuſe of Non-Naturals, the Ferments of the *Viſcera* are perverted; and by the faults of the Pancreatick juice and of the Spleen, an Acid or Auſtere Salt is carried forth into a flux; preſently the Maſs of Blood is vitiated. The Animal Spirits

meeting with this vitious Salt, and fermenting in the *Glands*, do there cauſe irregular Exploſions of matter, into the Carnous Fibers, ſubtilized in that Fermentation; whence follow irregular Contractions of the Muſcles.

Why Convulſive Paroxyſms come at uncertain times, will eaſily appear, if we do but conſider the Procatartick Cauſes; amongſt which I ſhall only mention two, *viz.* The Quantity of Morbifick matter irritating Nature to an Expulſion of it; and ſudden Paſſions of the Mind.

The Quantity of Morbifick matter is far greater in ſome Bodies than in others, before the

the Spirits are able to recover themſelves, and to endeavour an Expulſion of it : In the former Caſe, Convulſions are Univerſal and ſeiſe the whole Body; in the Latter Particular, the Morbifick matter being accidentally driven more on one Part than another. Again in ſome Bodies it is ſooner heaped up, being generated in greater quantities.

The Matter heaped up, at the firſt is very crude and thick, and although it be caſt forth into, and Circulates through, the Muſculous parts, and continually Ferments with the Spirits in the *Glandules* ; yet becauſe it is not ſufficiently

attenuated to be driven forth into the fleſhy Fibers, till by frequent Circulations and Fermentations, it is exalted from it's ſtate of fixedneſs to a more Volatile, no Convulſions ſucceed. Moreover as long as it continues in its ſtate of Crudity, the Animal Spirits are much dulled and their Activity quaſhed by mixing with it, but it being at the length ſubtilized and rarified by frequent Circulations, the AnimalSpirits recovering 'em ſelves, and violently Fermenting with it in the *Glands* carry this Vitious *juice* exploſively into the Fibers. The Reaſon why this Motion is Involuntary, is, becauſe it is not produced by a

greater

greater quantity of Spirits flowing from the Brain, accordingly as the Pores are dilated by our Appetite, but by a mixture of Morbifick and Fermentitious Particles, which cauſe Preternatural Fermentations & Expulſions of Matter Attenuated thereby.

Convulſive fits are ſometimes brought on, before the Morbifick matter gradually arrives at this ſtate of tenuity, when upon ſudden Paſſions of the Mind, the Animal Faculties quit their Stations, and being overpower'd by external Objects can no longer moderate the Emanations of the Animal Spirits. The Formal Cauſe of the Irregular Emanations of the Spirits in theſe Convulſions is this; the

Pores

Pores of the Brain being ſhut up, to keep out external Objects, heap up the Spirits, till by Reaſon of their quantity, the Pores can no longer retain them; and then the Spirits ruſh out *quà datur portà* in a greater quantity, and violently ſetting upon the Crude *juice*, which they meet with in the *Glandules*, ſtrongly Ferment Attenuate and carry it forth into the Fibers, of the Muſcles wherein the Spirits are thus accidentally laid down: The Brain being thus emptied, the Pores are ſhut up again, till the quantity of Spirits make way again; and ſo ſucceſſively follow Convulſive Motions, in this or that Part where-ever the Spirits ſet upon the Crude Morbifick Matter.

The

The Palpitation of the Heart, as the Learned Dr. *Willis* has noted, sometimes proceeds from Convulsive Motion: The Reason why the Morbifick Matter only shews it self in this part, and at the same time in no other parts of the Body is this. The Mass of Blood is impregnated with a Morbifick taint, and whatever is the Nature of it, since it is dispersed through the whole Body, one might Rationally expect Universal Convulsions as well as Particular: But this Morbifick Matter being as yet Crude, and not of a sufficient Quantity to irritate Nature,

Of the Palpitation of the Heart.

Nature in all the Parts of the Body; theſe Effects are only produced in this Part, where a large Quantity of Spirits is continually laid down to ferment with it; by which means it is Subdued in this Part, before it arrives at ſuch a State of Activity or ſuch a Quantity, as to cauſe irregular Fermentations and Contractions in other Parts.

Τέτανος, Ἐμπροσθότονος, Ὀπισθότονος.

In a Τέτανος, Ἐμπροσθότονος, Ὀπισθότονος, The Muſcles continue conſtantly contracted againſt our Appetite; theſe Diſtempers ſeize People, whoſe Blood is rather of a Vitriolick Tenacious Nature,

ture, and impregnated with more Fermentative Spirits; ſo that by reaſon of the Viſcidity of the Matter violently forced into the Fibers, either the Lymphæducts are obſtructed, or by reaſon of a continual Fermentation, Matter gradually ſucceeds.

of the Cramp.

In the Cramp, the Fermentation is different from that which is Natural, or in other Convulſive Motions; that which is Natural, being cauſed by the Animal Spirts preparing a Subtil and Homogenious Liquor: In other Convulſions the Animal Spirits ferment with, and

and endeavour to ſubdue a Morbifick Humour brought and layed down by the Arteries, and the Matter thus attenuated, is accidentally forced into the Fibers: But theſe are cauſed by the continual Conflict of the Volatile Animal Spirits, ſtrongly fermenting with Fermentative and Elaſtick Particles of another Nature, ſupplied by the Maſs of Blood; where both ſtriving to ſubdue each other, the Elaſtick Particles of the Blood, more ſtrongly oppoſe the Motion of the Spirits, and the Spirits them, by a contrary agitation and inteſtine Motion of their Particles; and theſe Two being violently exploded, and impetuouſly leaping

ing

ing into, and fermenting in the Fibers, cauſe moſt ſtrong and painful Contractions.

Of the Subſultus Tendinum *in Fevers.*

The *Subſultus Tendinum* in Fevers are cauſed, when the Spirits being too much exalted, leap irregularly out of the Brain, and raiſe the Fermentation in the Glands ſo high, as to prepare and carry too much of the Subtile *Liquor* into the Fibers; which becauſe it is ſo very thin, eaſily ſlips into the Lymphæducts, and makes the Contraction ſhort.

I ſhall

I ſhall add the Reaſon only of one other *Phæno-menon*, which ſeems more evidently to prove, that Muſcular Motion depends on the greater influx of Animal Spirits, *viz.* Why the Contraction of one Muſcle followeth, when the Antagoniſt becomes Paralytick, as in *Spaſmus Cynicus*: The Branches of the Nerves being derived from the Brain, when the Influx of the Spirits into the Muſcles of the one ſide are hindered, they regurgitate, and are driven preſently in a greater quantity into the Antagoniſt; as by the Loſs of one Eye, the other, by a greater Influx of Spirits, becomes

Of a Spaſmus Cynicus.

becomes more Acute: This is evident, and needs no further proof.

Thus I have laid down my Hypotheſis of the Formal and Efficient Cauſes of Muſcular Motion, and how it is vitiated or depraved; which I the more willingly commit to the Judgment of Learned and Competent Judges, with due Submiſſion; becauſe it ſeems to me to anſwer Natural Ends, and to account for the ſeveral *Phænomena*, without the Difficulties, Enormous Motions and Impoſſibilities, which uſually attend Hypotheſes on this Subject; not doubting, but it will

will give ſatisfaction, till one more probable and plauſible ſhall ſucceed.

FINIS.

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